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Woodsmoke Air Pollution and Changes in Pulmonary Function Among Elementary School Children

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INTRODUCTION

Klamath Falls, a Southern Oregon community with a population of 37,500, has had recurrent episodes of elevated air pollution levels due to respirable particulate matter (PM_{10}). These air pollution episodes have occurred in winter months, during periods of air stagnation, temperature inversion, and heavy use of woodstoves for home heating.

PM_{10} level data for a three year period, shown in Figure 1, reveal violations U.S. Environmental Protection Agency's National Ambient Air Quality Standards (NAAQS) during the winter heating season. Some of the nation's highest PM_{10} pollution levels have been recorded in this community. Woodsmoke from home heating with woodstoves accounts for an estimated 64.6% of the annual PM_{10} emissions in the Klamath Falls Air Quality Control Area[1]. During winter worst day emissions, woodsmoke may account for 81% of the PM_{10} pollution.

PM_{10} air pollution tends to concentrate in areas of the community corresponding to a geologic depression, which lies 65-90 feet below the average elevation of the city. Figure 2 shows the typical pattern of air pollution in Klamath Falls.

Local health authorities and the State Department of Environmental Quality have been monitoring the situation for a number of years. They have been coordinating efforts to reduce woodstove air emissions in this community through a program of voluntary curtailment of woodstove use during severe periods of air inversion. Because of concern about adverse health effects from woodstove smoke exposure to the residents of the community, the Oregon Health Division was asked to investigate this issue.

Several studies conducted in the United States and Europe have found an association between exposure to elevated levels of outdoor air pollution and increased frequency and rate of respiratory illness among school age children[2-6]. The Six Cities study of air pollution and health identified an association between particulate air pollution and reported rates of symptoms of illness including chronic cough, bronchitis, and chest illness[2]. However, this study did not demonstrate any significant change in lung function measures among the children studied. Measurable short-term declines in lung function were demonstrated in the Federal Republic of Germany and in Steubenville, Ohio, following air pollution episodes involving elevated total suspended particulates (TSP) and sulfur dioxide (SO_2) levels[4,5]. Atmospheric PM_{10} levels were found to be strongly associated with hospital admissions for respiratory illness among children in one Utah county experiencing fine particulate pollution from a steel mill[6].

Indoor heating with woodstoves has been linked with the occurrence of chronic respiratory symptoms in young children[7]. A variety of other indoor air pollutants have also been associated with increased rates of respiratory illness[7-9].

Methods

<u>Lung Function Measurement</u>. The Oregon Health Division designed a pilot study to measure seasonal changes in pulmonary function tests (PFT) among elementary school children in grades three through six. This age group has been shown to be acceptable for such study in similar investigations reported in the literature[2,5,7]. They are able to perform the spirometry maneuvers, and are easily accessible through local schools. Three area schools were chosen based on their proximity to high and low PM_{10} air pollution levels (see Figure 2). Peterson and Stearns Schools are located in the high exposure area. Conger School is located in a lower exposure area to the northwest of the geologic depression.

Parents of eligible school children were asked to enroll their child(ren) in the study. Participation was voluntary.

The pilot study used a repeated measures design in which PFT data were obtained on the same children at three points in time. Time 1, the baseline measurement, was conducted in October 1989, before the onset of the heating season. Measurements at Time 2 were obtained during the winter heating season (March, 1990). Follow-up measurements (Time 3) were obtained after the end of the heating season (late May and early June, 1990).

The field technician team consisted of staff members of Klamath County Department of Health Services. They were trained to conduct the lung function measurements according to the American Thoracic Society (ATS) protocol.[illegible] Three ATS approved, Spiromate AS 600 computerized portable spirometers were used (Riko Medical Instruments).[illegible] The spirometers were calibrated according to the manufacturers specifications.[illegible]

Pulmonary function testing followed ATS protocols for data quality and acceptability.[illegible] Children performed the spirometry maneuvers in a standing position. They did not wear nose clips. Each child had up to eight attempts to obtain at least three acceptable maneuvers. Values were corrected to body temperature and pressure, and fully saturated with water (BTPS). Standing height in stocking feet was recorded for each child at the time of testing.

PFT measurements included: forced expiratory volume at one second ($FEV_{1.0}$) measured in liters, forced vital capacity (FVC), measured in liters, and peak expiratory flow (PEF), measured in liters per second. The ratio of $FEV_{1.0}$ to FVC (FEV_1/FVC) was calculated from the data.

The technicians worked in parallel at each of the three schools. Children were randomly assigned to a technician for the baseline measurements. Each child was tested by the same technician, on the same spirometer for both of the subsequent test periods. This was done to control for inter-observer bias.

Predicted values for each child's lung function measurements were calculated using published equations which account for the child's height at the time of testing, sex, and race.[illegible] Observed FEV_1 and FVC values were compared to the child's predicted values to obtain the percent of predicted at each measurement time. Acceptable data had to meet the test of reproducibility. The two highest FEV_1 values for each [illegible] had to be within 0.1 liter of each other. Likewise, the two highest FVC values had to be within 0.1 liter of each other.

This report presents findings of the changes in FEV_1 [illegible] time. FEV_1 [illegible] considered to be the [illegible] spirometry variable for detecting airflow obstruction.[illegible]

Survey. In addition to spirometry, a questionnaire was developed using the ATS model[illegible] and mailed to the parents of children enrolled in the study. The survey sought information on the child's lung health, home exposure to woodstoves, tobacco smoke, cooking fuel and pets along with other pertinent demographic, health and socio-economic data.

Analysis. Data analysis examines the change in mean or average lung function values over time. Analysis first compares the changes between the high and low outdoor exposure groups. The association of home woodstove usage and changes in mean lung function is examined by home use of a woodstove, independent of outdoor exposure area. Data are then analyzed combining home woodstove use and outdoor exposure area. The relationship between tobacco smoke and lung function is explored next. Finally, a multiple

linear regression analysis is performed. This enables the interaction among the different variables to be examined.

<u>Ambient Monitoring</u>. Air monitoring for PM_{10} was conducted by the Department of Environmental Quality in both the high and low exposure areas. Peterson School, in the high exposure area, is the permanent site of an ambient air quality monitoring station which records continuous measurements on a year-round basis. This monitoring station reflected pollution levels for both schools in the high exposure area. A second station was set up a Conger School in the lower exposure area to measure PM_{10} levels during the study period.

Each station employed an integrating nephelometer which continuously monitored the smokiness of air by measuring the light scattering coefficient inside a chamber. Hourly levels were calculated by an internal computer. Due to limited availability of the equipment, ambient air monitoring in the low exposure area was only conducted between early November, 1989, and mid-March, 1990.

Results

PM_{10} air pollution levels in Klamath Falls were lower during the winter of 1989-90, than those recorded in previous years. (See Figure 1 for comparison). This was due in part to warmer than usual winter temperatures as well as an increased level of voluntary compliance with local efforts to reduce woodstove use during air inversion episodes. In addition to being less intense, the pattern of air inversions differed from previous years. The most severe and persistent inversions occurred during December instead of the period from late January through March--as in prior years.

Comparison of 24-hour average PM_{10} levels between high and low exposure areas is presented in Figure 3. Particulate levels measured in the high exposure area around Peterson School exceeded the NAAQS on 45 days during the 1989/90 heating season. Particulate levels were consistently lower in the area around Conger School (the low exposure area), exceeding the NAAQS only once during the study period.

A total of 464 elementary school children were originally enrolled in the study. Three completed sets of acceptable lung function measurements were obtained from 410 (88.4%) of the children. Data from the child health survey were received for 310 (75.6 percent) of these children. Children, for whom complete lung function data or survey information were lacking, did not differ significantly from the remainder of the study population in terms of age, sex and area of residence.

Table 1 presents the demographic characteristics of the children in the study for whom we had three complete sets of acceptable data. Forty-nine percent of the study population were males, and 51 percent were females. The overwhelming majority of the population was white. A small number of Hispanic, Native American, and African American students were also included in the study population. This pattern closely reflects the racial make-up of the three schools studied.

The average age of the children was 10 years, with a range from 7 to 14 years of age. Peterson Elementary School accounted for 44 percent of the study population, while Stearns School accounted for approximately 38 percent, and Conger School 18 percent. The level of participation in the study was 69% of eligible children from Peterson School, 60% of eligible children from Stearns School, and 66 percent of eligible children from Conger School. Children from Peterson and Stearns Schools live in the high exposure area of the study (n = 335). Children from Conger School live in the low exposure area (n = 75).

Table 2 presents a comparison for selected demographic and related characteristics between high and

low exposure areas. The average length of residence in the community was similar for children living in both the high and low exposure areas, based on the responses from parents to the child health questionnaire. Children in the high exposure area (Peterson and Stearns Schools) had a mean length of residence of 5.0 years. Children in the low exposure area (Conger School) lived in the area for an average of 5.4 years. The difference was not statistically significant.

The average reported level of parental income for the high exposure area was $29,000, and $32,000 for the low exposure area. This difference was not significant.

Mother's level of education was the same for both exposure areas, 13 years. However, father's level of education differed between the two exposure areas. Fathers in the high exposure area had completed an average of 12 years of school, while fathers in the low exposure area completed an average of 14 years of school. This difference was significant ($p < .001$).

Reported woodstove use was similar for both exposure groups. In the high exposure area, 72.5% of the children lived in homes that used a woodstove for part or all of their heating needs. Among children in the low exposure area, 70.7% lived in homes that utilized woodstove heat.

Tobacco smoke exposure was known for 276 of the children. In the high exposure group, 64% of the children were reported to have some exposure to tobacco smoke. This compares to only 46% of the children in the low exposure group. This difference was significant at the $p = .02$ level.

Asthma status was determined for each child through the child health survey. Approximately 10 percent of the children had been diagnosed by a physician as being asthmatic. Another 19 percent of the children had two or more symptoms compatible with undiagnosed asthma. The distribution of asthmatics was similar between high and low exposure areas.

Change in mean (average) PFT as measured by $FEV_{1.0}$ was calculated for each exposure area (see Figure 4 and Table 3). Children in the high exposure area showed a decrease in the mean $FEV_{1.0}$ from baseline (Time-1) to winter (Time-2). The average values declined 2.3% during this interval ($p = .002$). The mean $FEV_{1.0}$ declined an additional 2.2% from the winter (Time-2) to Spring (Time-3) measurements ($p < .001$).

Children in the lower exposure area showed essentially no change in mean $FEV_{1.0}$ between Time-1 and Time-2 (see Figure 4 and Table 3). There was a slight decline (0.8%) in mean $FEV_{1.0}$ from Time-2 to Time-3.

Figure 5 presents mean $FEV_{1.0}$ levels by woodstove exposure for the entire population. Children in homes where woodstove heat was used experienced a decline in $FEV_{1.0}$ of 2.7% between Time-1 and Time-2 (see Table 4), while those children in homes without woodstove heat experienced no change in lung function during the same time frame. Both exposure groups showed declines in mean $FEV_{1.0}$ values between Time-2 and Time-3 (-1.7% for those exposed to a woodstove in the home and -3.0% for those not exposed).

The impact of woodstove use was examined by exposure area (Figure 6). Children in the high exposure area who live in homes with wood heat had significant declines in $FEV_{1.0}$ from Time-1 to Time-2, and again from Time-2 to Time-3 (3.3% $p < .001$ and 1.5% $p = .05$, respectively [see Table 5]).

Children living in the high exposure area who did not have woodstove heat in their homes had essentially no change in lung function (0.8%) from Time-1 to Time-2. They did, however, exhibit a significant decline between Time-2 and Time-3 (4.2% $p < .001$).

Children in the lower outdoor exposure area, who live in homes heated by woodstoves showed no change (0.2% decline) in mean $FEV_{1.0}$ between Time-1 and Time-2. These children did, however, show a decline in lung function of 2.5 % from Time-2 to Time-3 ($p = .004$).

Children in the lower exposure area who live in a home with no woodstove showed a statistically insignificant increase in lung function of 2.7%, from Time-1 to Time-2. This pattern of increase continued from Time 2-to Time-3 (1.1% increase).

Figure 7 presents the mean $FEV_{1.0}$ over time, by tobacco exposure, for all children for whom this was known. Children with no reported exposure to tobacco smoke baseline levels markedly higher than children who were exposed to tobacco smoke (94.8%, 92.2%, respectively). These differences, however, were not statistically significant (see Table 6). Mean lung function declined 2.5% ($p = .02$) between Time-1 and Time-2 for children with no tobacco exposure, while children who were exposed to tobacco smoke had declines of 0.8% (not significant). Both groups experienced similar declines between Time-2 and Time-3 (-1.7% for the not exposed group and -2.2% for the exposed group). The numbers of subjects with information about smoking are too small to conduct analysis by either exposure area or woodstove use.

The major variables of interest were combined in a multiple linear regression analysis. Outdoor exposure area and home use of a woodstove were both significantly associated with declines in $FEV_{1.0}$ between Time-1 and Time-2. Exposure to tobacco smoke, asthma status, parent's income, and parent's education were not statistically associated with changes in $FEV_{1.0}$.

Summary

Temperatures were warmer during the winter of 1989/90 than in previous years when PM_{10} levels had been measured. Pollution levels were also lower during this winter and they occurred in December which was earlier than in previous years. Monitoring stations demonstrated that ambient PM_{10} pollution levels were consistently higher in the high exposure area than in the low exposure area.

There were no differences between the two outdoor exposure groups in terms of age, race, parental income, length of residence in the community, or the use of woodstoves for heat. The two groups were statistically different in terms of father's education, exposure to tobacco smoke, and exposure to ambient levels of PM_{10} pollution.

Significant decreases $FEV_{1.0}$ from baseline (Time-1) to winter (Time-2) were observed among children in the high exposure schools. Significant decreases in $FEV_{1.0}$ were also observed between Time-2 and Time-3 (after the winter heating season) among children in the high exposure area. $FEV_{1.0}$ also declined during this latter time period among children in the lower exposure area. Among the study population, asthma status was not associated with a decline in lung function.

Children in homes heated by woodstoves showed greater declines in $FEV_{1.0}$ than children in homes that did not use woodstove heat. The association between home woodstove use and lung function was evident among children living in both high and low outdoor pollution exposure areas.

Lung function measures either remained low or declined further between Time-2 and Time-3. This was an unexpected finding, seen among virtually all of the children in the study population. It is possible that a greater amount of time is needed for lung function to return to normal (baseline) following approximately five months of exposure to elevated PM_{10} levels. It is also possible that some event or exposure, unexplained by the variables analyzed, was the cause of this decline.

CONCLUSIONS

Analysis of the data indicates that there was a significant decrease in average pulmonary function measurements among children in the high exposure area during the winter months when outdoor PM_{10} levels were elevated. This finding is consistent with results from other studies published in the literature[2-8].

Additionally, the results of this pilot study found indoor woodstove exposure during winter months to be significantly associated with declines in children's $FEV_{1.0}$ levels. Indoor woodstove exposure may be a more important determinant of children's lung function than exposure to outdoor PM_{10} air pollution. Further study is needed to test this hypothesis.

Children in this study, who were exposed to tobacco smoke at the time of the baseline spirometry measurements had markedly lower lung function measurements than children who were not exposed. Children not exposed to tobacco smoke had significant declines in lung function measurements during the period of increased ambient PM_{10} pollution levels. Their mean $FEV_{1.0}$ levels dropped to those of the children who were exposed to tobacco smoke.

This pilot study was not designed to be a definitive evaluation of the health effects of woodstove smoke exposure among elementary school aged children in Klamath Falls. A short time frame for planning and insufficient funding were clear limitations in this project. For example, we were unable to conduct a double baseline prior to the heating season, nor were we able to test pulmonary function during the peak exposure time which occurred earlier in the winter than was expected.

Furthermore, the focus of this study was to examine changes in pulmonary function among elementary school children over a specified time period. This study did not consider all possible health effects which may be associated with outdoor or indoor wood smoke air pollution exposure. Nor are the findings necessarily generalizable to other age groups which may be susceptible to this type of pollution.

Nevertheless, several significant associations have been identified in this study. Additionally, important questions are raised by this study which could be addressed through further investigation and with the appropriate funding. These questions include:

A. What indoor pollutants are the children exposed to during the winter heating season?

B. How do the indoor pollutant levels compare with outdoor levels for homes using woodstove heat versus homes with other sources of heat, and how is this affected by weatherization status?

C. Would children's lung function changes be even greater if we had the flexibility to conduct testing at the absolute peak period of PM_{10} pollution?

D. What is occurring during spring which might further affect children's lung function (e.g., cumulative effects of air pollution exposure, high pollen counts, continued short duration [4-6 hours] high PM_{10} pollution levels occurring at nights, reaction to ambient silica dust exposure, or outbreaks of respiratory illness)?

We hope to be able to address these questions in the future.

REFERENCES

1. Oregon Department of Environmental Quality. 1989 Oregon Air Quality Annual Report. DEQ, Air Quality Division, 1990.

2. D.W. Dockery, F.E. Speizer, D.O. Stram et al., "Effects of inhalable particles on respiratory health of children." Am. Rev. Respir. Dis. 139: 587 (1989).

3. F.E. Speizer, B. Ferris, Y.M.M. Bishop, J. Spengler, "Respiratory disease rates and pulmonary function in children associated with NO_2 exposure." Am. Rev. Respir. Dis. 121: 3 (1980).

4. D.W. Dockery, J.H. Ware, B.G. Ferris, et al., "Change in pulmonary function in children associated with air pollution episodes." J. Air Pollut. Control Assoc. 32: 937 (1982).

5. W. Dassen, B. Brunekreff, G. Hoek, et al., "Decline in children's pulmonary function during an air pollution episode." J. Air Pollut. Control Assoc. 36: 1223 (1986).

6. C.A. Pope, III., "Respiratory disease associated with community air pollution and a steel mill, Utah Valley." Am. J. Public Health 79: 623 (1989).

7. J.S. Osborne, R.E. Honicky, "Health effects of heating with wood: chest illness in young children and indoor heating with woodburning stoves." in Proceedings of the 1989 IAQ on The Human Equation: Health and Comfort, ASHRAE/SOEH, Atlanta, 1989, pp 17-22.

8. V. Hasselblad, C.G. Humble, M.G. Graham, H.S. Anderson, "Indoor environmental determinants of lung function in children." Am. Rev. Respir. Dis. 123: 479 (1981).

9. C.S. Berkey, J.H. Ware, D.W. Dockery, et al., "Indoor air pollution and pulmonary function growth in preadolescent children." Am. J. Epidemiol. 123: 250 (1986).

10. B.G. Ferris, Jr., "Epidemiology standardization project." Am. Rev. Respir. Dis. 118: 7 (1978).

11. American Thoracic Society, "Standardization of spirometry-1987 update." Am. Rev. Respir. Dis. 136: 1285 (1987).

12. P. Enright, R.E. Hyatt, Office spirometry, Lea & Febiger, Philadelphia, 1987, p 253.

13. Riko Medical & Scientific Instrument Corp. Spiromate AS-600 operation manual.

14. K.H.K. Hsu, D.E. Jenkins, B.P. Hsi, et al., "Ventilatory functions of normal children and young adults--Mexican-American, white, and black. I. Spirometry." J. Pediatrics 95: 14 (1979).

15. M.A. Wall, D. Olson, B.A. Bonn, et al., "Lung function in North American Indian children: reference standards for spirometry, maximal expiratory flow volume curves, and peak expiratory flow." Am. Rev. Respir. Dis. 125: 158 (1982).

16. A.S. Buist, Textbook of Respiratory medicine, J.F. Murray and J.A. Nadel, eds. W.B. Saunders Co., Philadelphia, 1988, pp 1001-1029.

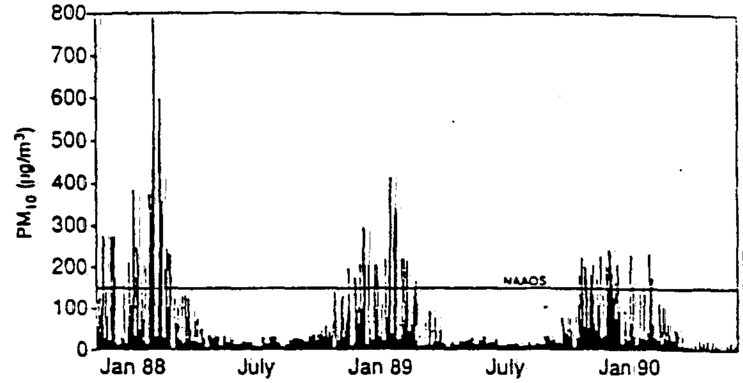

FIGURE 1 Klamath Falls PM_{10} levels.
November 1987 to July 1990

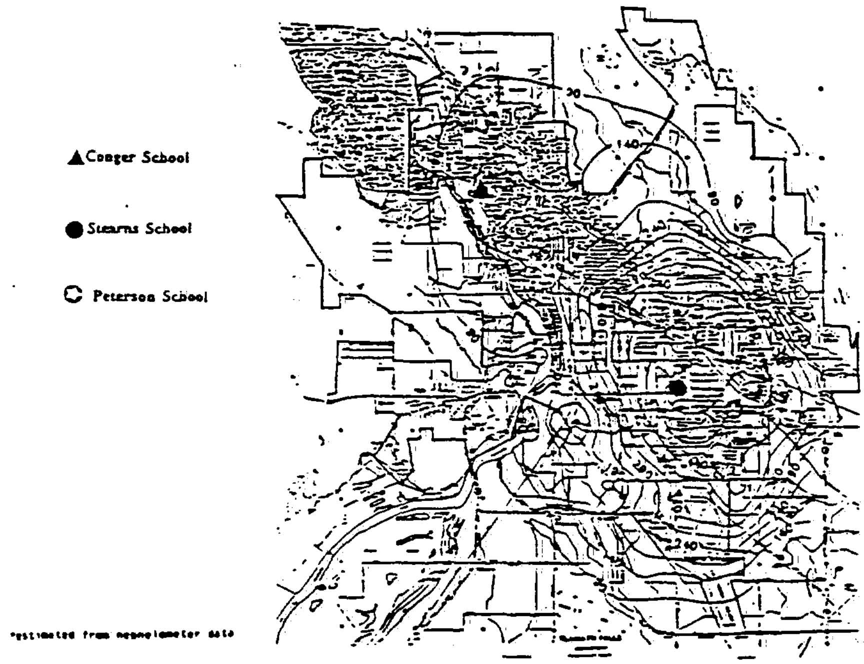

FIGURE 2 Klamath Falls nephelometer survey
January 26, 1989, 9:00 p.m.
($\mu g/m^3$ PM_{10}, 5 minutes averages)*

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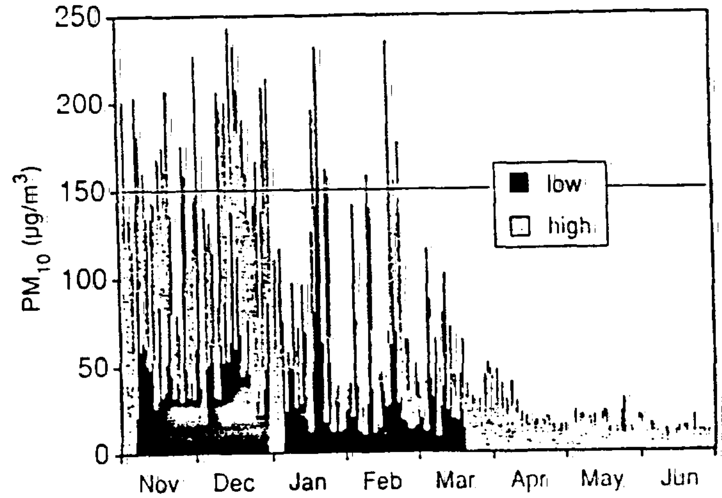

FIGURE 3 Klamath Falls PM_{10} levels by exposure area. November 1989 - June 1990

NOTE TO EDITORS

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TABLE 1 Selected demographic variables for the study population, N = 410.

		Study Population	
		Number	Percent
SEX			
male		201	49.0
female		209	51.0
RACE			
white		388	94.[illegible]
Hispanic		14	3.4
Native American		5	1.2
African American		3	0.7
AGE			
range	7 - 14 years		
median age	10 years		

TABLE 2 Selected demographic variables by exposure area

	High Exposure Area Number	(%)	Low Exposure Area Number	(%)	Level of Significance
AVERAGE LENGTH OF RESIDENCE					
in years	5.0		5.4		NS*
FAMILY INCOME					
median	$29,000/year		$32,000/year		NS*
PARENTAL EDUCATION					
Father (median)	12 years		14 years		[illegible]
Mother (median)	13 years		13 years		NS*
HOME WOODSTOVE USE					
yes	166	(72.5)	41	[illegible]	NS*
no	63	(27.5)	[illegible]	[illegible]	NS*
ASTHMA STATUS					
physician diagnosed	24	(10.2)	[illegible]	(11.9)	NS*
history of symptoms	43	(18.3)	[illegible]	(20.3)	NS*
no asthma	168	(71.5)	40	(67.8)	NS*
TOBACCO EXPOSURE					
yes	140	(64.6)	25	(46.4)	.02
no	80	(36.4)	30	(53.6)	.02

* Not Significant

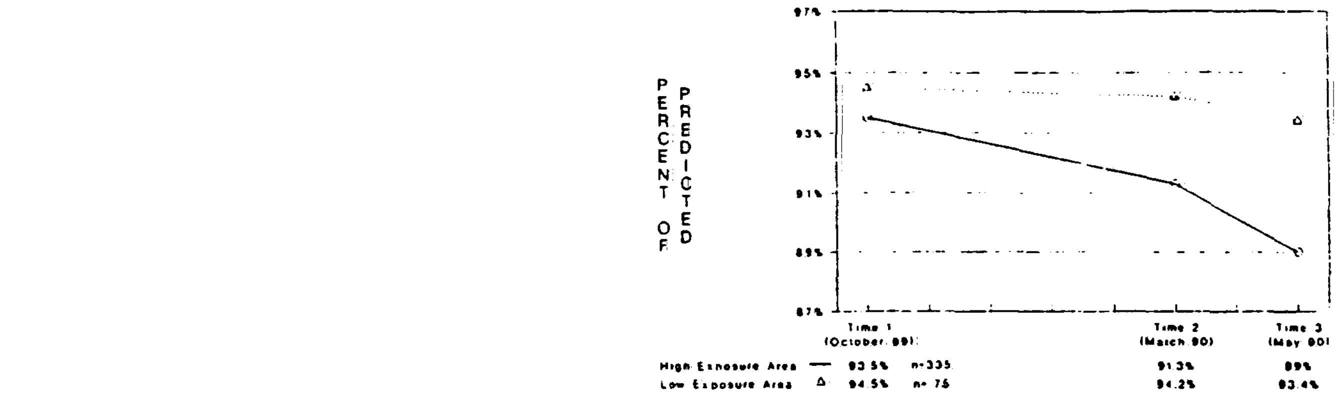

FIGURE 4 Change in mean FEV 1.0 for elementary school children by exposure area, N = 410.
Klamath Falls, Oregon, 1990

TABLE 3 Change in mean lung function among elementary school children over the study period by exposure area, N = 410.
Klamath Falls, Oregon, 1990

		% of Change in Mean Value & Level of Significance			
		Baseline to Winter		Winter to Spring	
Exposure Area	Lung Function Measure	%	P*	%	P*
High Exposure n = 335	$FEV_{1.0}$	-2.3	.002	-2.2	< .001
	FEV/FVC	-1.1	< .001	-0.3	NS**
Low Exposure n = 75	$FEV_{1.0}$	-0.3	NS**	-0.8	NS**
	FEV/FVC	-0.2	NS**	-0.7	.04

*P – Level of Significance From Paired t-Test
NS** Not significant at P = .05

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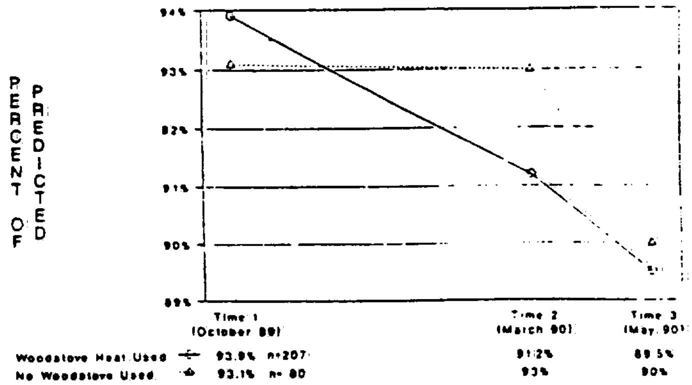

FIGURE 5 Change in mean FEV 1.0 for elementary school children, by home woodstove exposure, N = 287.
Klamath Falls, Oregon, 1990

TABLE 4 Change in mean lung function among elementary school children over the study period by home woodstove use, N = 287.
Klamath Falls, Oregon, 1990

Status of Woodstove Use	Lung Function Measure	% Change in Mean [illegible]			
		Baseline to Winter		[illegible]	
		%	[illegible]	[illegible]	[illegible]
Home Woodstove Used N = 207	$FEV_{1.0}$	-2.7	[illegible]		[illegible]
	FEV/FVC	[illegible]	[illegible]	[illegible]	[illegible]
No Woodstove Used N = 80	$FEV_{1.0}$	-0.1	NS**	[illegible]	[illegible]
	FEV/FVC	-1.3	[illegible]	[illegible]	[illegible]

P = Level of Significance From Paired t-Test
NS** = Not significant at P = .05

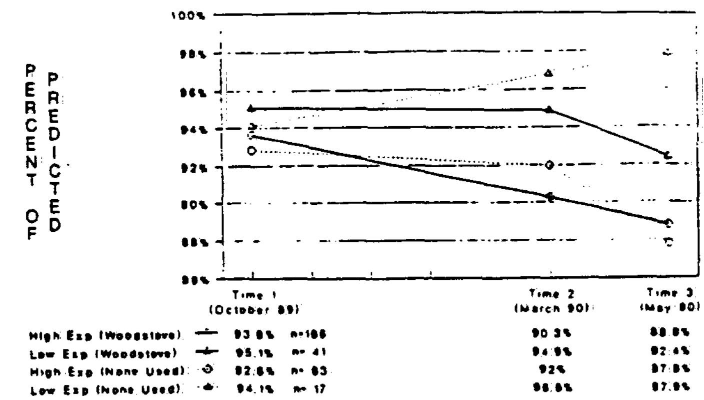

FIGURE 6 Change in mean FEV 1.0 for elementary school children, by exposure area and woodstove use, N = 287.
Klamath Falls, Oregon, 1990

TABLE 5 Change in mean lung function among elementary school children over the study period by exposure area and by home woodstove use, N = 287.
Klamath Falls, Oregon, 1990

		Woodstove Used in Home				No Woodstove			
		Percent Change in Mean Value				Percent Change in Mean Value			
		Baseline to Winter		Winter to Spring		Baseline to Winter		Winter to Spring	
Exposure Area	Lung Function Measure	%	P*	%	P*	%	P*	%	P*
High Exposure n = 229	$FEV_{1.0}$	-3.3	< .001	-1.5	.05	-0.8	NS**	-4.2	< .001
	FEV/FVC	-0.7	NS**	+0.3	NS**	-1.4	.007	0.0	NS**
Low Exposure n = 58	$FEV_{1.0}$	-0.2	NS**	-2.5	.004	+2.7	NS**	+1.1	NS**
	FEV/FVC	-0.3	NS**	-1.1	.04	-0.7	NS**	+0.3	NS**

* = Level of Significance from Paired t-Test
** = Not Significant at P = .05

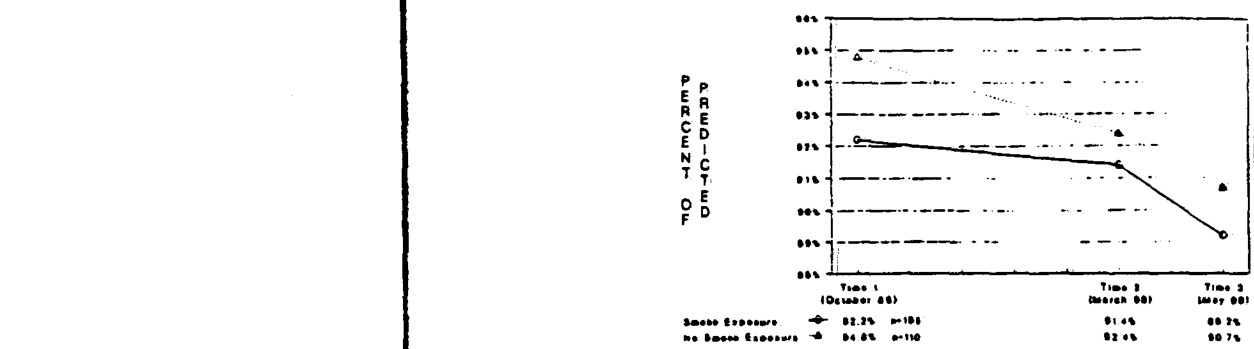

FIGURE 7 Change in mean FEV 1.0 for elementary school children, by tobacco smoke exposure, N = 276.
Klamath Falls, Oregon, 1990

TABLE 6 Change in mean lung function among elementary school children over the study period by exposure to tobacco smoke, N = 276.
Klamath Falls, Oregon, 1990

		% of Change in Mean Value & Level of Significance			
		Baseline to Winter		Winter to Spring	
Exposure	Lung Function Measure	%	P*	%	P*
Exposure to Tobacco Smoke N = 166	$FEV_{1.0}$	-0.8	NS**	-2.2	.009
	FEV/FVC	-0.9	.023	-0.1	NS**
No Exposure N = 110	$FEV_{1.0}$	-2.5	.02	-1.7	.03
	FEV/FVC	-0.8	NS**	0.0	NS**

* = Level of Significance From Paired t-Test
** = Not Significant at P = .05

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